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THESIS

A METHODOLOGY FOR DETERMINING STUDENT VALUE IN EXPLOITING AIRLINE RESERVATION TECHNOLOGIES TO IMPROVE NAVY TRAINING QUOTA MANAGEMENT

by

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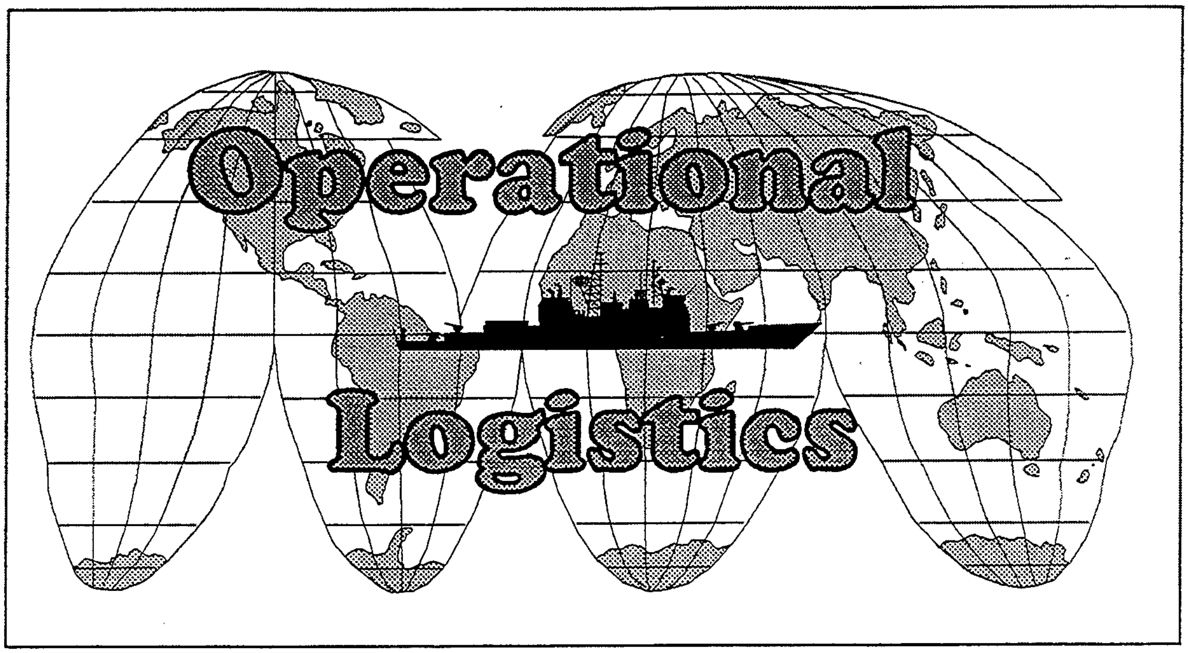
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The Navy trains over 350,000 students a year. Quotas for the number of students to train are based on current and projected manning levels, as well as anticipated force requirements. Last year, students awaiting instruction exceeded 1.3 million mandays while, simultaneously, over 25% of the Navy's 330,000 technical training seats went unfilled. The number of unfilled seats in classrooms, coupled with the large number of students awaiting instruction, identified the need to more closely manage the allocation of quotas. The use of yield managment has been explored to determine if airline reservation technologies are applicable to solving the Navy training quota management problem. In order to apply yield management to the Navy training problem, the concept of value must be determined as it relates to a student attending a Navy training class. While airlines measure value in revenue generated, the Navy has no way of placing value on a particular student attending a particular class. This thesis identifies a methodology for determining student value within the Navy Training Quota Management System.

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A METHODOLOGY FOR DETERMINING STUDENT VALUE IN EXPLOITING AIRLINE RESERVATION TECHNOLOGIES TO IMPROVE NAVY TRAINING QUOTA MANAGEMENT

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ABSTRACT

The Navy trains over 350,000 students a year. Quotas for the number of students to train are based on current and projected manning levels, as well as anticipated force requirements. Last year, students awaiting instruction exceeded 1.3 million mandays while, simultaneously, over 25% of the Navy's 330,000 technical training seats went unfilled. The number of unfilled seats in classrooms, coupled with the large number of students awaiting instruction, identified the need to more closely manage the allocation of quotas. The use of yield managment has been explored to determine if airline reservation technologies are applicable to solving the Navy training quota management problem. In order to apply yield management to the Navy training problem, the concept of value must be determined as it relates to a student attending a Navy training class. While airlines measure value in revenue generated, the Navy has no way of placing value on a particular student attending a particular class. This thesis identifies a methodology for determining student value within the Navy Training Quota Management System.

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EXECUTIVE SUMMARY

The Navy trains over 350,000 students a year. Quotas for the number of students to train are based on current and projected manning levels, as well as anticipated force requirements. Last year, students awaiting instruction exceeded 1.3 million mandays while, simultaneously, over 25% of the Navy's 330,000 technical training seats went unfilled. The number of unfilled seats in classrooms, coupled with the large number of students awaiting instruction, identified the need to more closely manage the allocation of quotas. The use of yield management has been explored to determine if airline reservation technologies are applicable to solving the Navy training quota management problem. Yield management enables the airlines to sell the right seats to the right customers at the right prices. A quota management tool has been designed by SABRE Decision Technologies in Fort Worth, Texas to better control the booking of Navy training reservations. In order to apply yield management to the Navy training problem, the concept of value must be determined as it relates to a student attending a Navy training class. While airlines measure value in revenue generated, the Navy has no way of placing value on a particular student attending a particular class.

The Value Determination Model in this thesis uses four factors; Student Type, Path Type, Orders Type, and Rate/NEC to describe a methodology to determine student value within the Navy Training Quota Management System. The Constant Sum Method of Paired Comparisons is demonstrated as a tool to arrive at a hierarchical ranking of the factors that do not have a quantitative measure of value. In the Constant Sum Method,

subject matter experts are asked to make judgements about the relative importance of elements in pairs with regard to their possession of a certain common property. Once a range of values has been determined for each of the factors, the methodology explores how different weighting schemes affect the final value of different types of students. The result is a mechanism which helps facilitate the implementation of yield management principles to the Navy training quota management problem.

I. INTRODUCTION

The Navy trains over 350,000 students a year. The scope of this training ranges from basic instruction in shipboard firefighting to complex aviation maintenance and foreign languages. Quotas for the number of students to train in each area are based on current and projected manning levels, as well as anticipated force requirements. Last year, students awaiting instruction exceeded 1.3 million mandays while, simultaneously, over 25% of the Navy's 330,000 technical training seats went unfilled. The Naval Personnel Research and Development Center (NPRDC) in San Diego has contracted Sabre Decision Technologies (formerly known as American Airlines Decision Technologies) in Ft. Worth, Texas to apply the concept of "yield management" to the Navy training system. Yield management, as it applies to the airline world, is a mechanism to scientifically manage the entire reservation system to maximize revenue and minimize empty seats on departing flights. Pioneered by American Airlines, yield management techniques integrated into the Navy training system "means offering the right school seats to the right customers (e.g., active duty, reservists, foreign nationals) at the right time to maximize fleet readiness." (SABRE Decision Technologies, April 1996) The goal is to improve readiness while saving money. Mr. Thomas Blanco of NPRDC writes,

> yield management technologies will improve fleet manning/readiness by 195,000 mandays by reducing students awaiting classes by at least 15% and unfilled seats by as much as 25 percent. These efficiencies will also result in immediate annual cost avoidances of $2.5 million in per diem and in long-term annual cost avoidances of $14.5 million in Military Pay Navy (MPN) end strength authorizations. (Blanco, 1995)

Unique to the Navy training problem is the determination of value as it applies to the military. While airlines measure value in revenue generated, the Navy currently has no way of placing a value on a particular student taking a particular class. The concept of value is crucial to the implementation of yield management and quota control in the Navy Training Quota Management System (NTQMS). Value to the Navy will not be measured in dollars; in fact, the final determination of value is a dimensionless quantity. The goal of this thesis is to identify a methodology for determining the value to the Navy of a specific type of student receiving training in a specific type of class for implementation into the Navy Training Quota Management System.

II. BACKGROUND

A. YIELD MANAGEMENT

> In its 1987 annual report, American Airlines broadly described the function of yield management as 'selling the right seats to the right customers at the right prices'. While this statement oversimplified yield management, it does capture the basic motivation behind the strategy. A better description of yield management as it applies to the airlines is the control and management of reservations inventory in a way that increases (maximizes, if possible) company profitability, given the flight schedule and fare structure. (Smith, et al, 1992)

For yield management principles to be applicable, the following conditions must exist:

- There is a finite amount of available space.
- The available space must be used in a given time period.
- The customer behavior is uncertain.
- Demand for space is uncertain.
- There is a cost associated with overselling and underselling available space.

Uncertain demand means that customers do not always show for flights on which they are scheduled, while demand uncertainty is reflected in seasonality, response to changes in ticket price (i.e., sales, fare wars), etc.

B. YIELD MANAGEMENT APPLIED TO NAVY QUOTA MANAGEMENT

The number of unfilled seats in classrooms, coupled with large numbers of students awaiting instruction, identified the need to more closely manage the allocation of quotas. The following table shows how the business requirements associated with yield management can be applied to the Navy training problem.

Business Requirements	Application to the Navy
Finite Space	Training classes with constrained capacity
Space must be used in a given time	Classes must be booked from the time they are scheduled with quotas until the convene day
Customer behavior is uncertain	Student do not always show up for their classes, students cancel reservations at the last moment
Demand for space is uncertain	Cyclical demand behavior, new commissioning, decommissioning, changes in priority, deployment
Cost associated with overselling or underselling	Impact on fleet readiness, lost man-days, Awaiting Instruction (AI), Awaiting Training (AT), additional class convenings

Table 1. Yield Management Applications to Navy Quota Management

1. Navy Training Quota Management System (NTQMS)

The Navy Training Quota Management System (NTQMS) was designed as the tool to optimally allocate the number of quotas to each class convening based on historical data of student behavior. NTQMS is comprised of several modules and models: the Booking Level Authorization Module, the Demand Forecast Model, the Value Determination Model, the Quota Allocation Module, and the Quota Management Monitoring and Report Generation Module.

Seats in classrooms are analogous to seats on an airplane. When the class convenes (the plane leaves the gate) any unfilled seats are lost and cannot be filled for that convening class (flight). Yield management technology helps answer two critical questions:

1. How many seats should be made available for reservation for each class convening?
2. How should these seats be allocated among competing quotas?

a. Booking Level Authorization Module

The answer to the first question is determined by the Booking Level Authorization Module in the Navy Training Quota Management System. This model determines the total number of students, or quotas, to allocate to a specific convening of a specific class based on class capacity, mean and variance of the show-up rate, student value, and oversale cost. The show-up rate is the percentage of the students who have reservations and will be present when the class convenes.

> In the airline industry, overbooking is the practice of intentionally selling more seats than the available capacity in anticipation of cancellations and no-shows. This practice can be used in the Navy training environment as well. Booking cancellations can occur when a student formally drops a class before the start date or when a student does not complete a necessary prerequisite course and is intentionally set back. A no-show situation occurs when a student does not show up for a class and does not formally drop the class before its convene date. To offset the effects of anticipated cancellations and no-shows, the reservation system may accept a maximum number of reservations (authorization level) that exceeds class capacity. Ineffective authorization level decisions can be very costly. If an authorization is set too low, there is the potential of having empty seats when the class convenes. These seats could have been filled by students who were turned away, resulting in *spoilage*. On the other hand, if the authorization level is set too high, then sufficient space may not be available to accommodate all the students who have a reservation, resulting in *oversale*. (Wang, et al, 1996)

American Airlines estimates that about 15 percent of seats on sold-out flights would be unused if reservation sales were limited to aircraft capacity.

b. Quota Allocation Module

Question two can be stated as follows: once it has been determined by how much the class will be oversold, how many of those seats are going to be allocated to the different types of students requesting training? In the airline industry, not all seats are immediately available for sale. The airlines intentionally withhold a certain percentage of

seats to be sold until within a narrow window of the date of departure. These seats can then be sold at a premium and generate the most revenue. In the Navy's case, the problem becomes how many seats to allocate to different student types. For example, if classroom capacity is 20 seats but the Booking Level Authorization Model determines that 25 seats should be "sold", the Quota Allocation Model determines how many of those seats should be available to each of the different student types competing for space in a given class, such as active duty Navy, Selected Reservists, foreign nationals, other branches of service, etc. The key to optimal quota allocation is the determination of value as it pertains to the different categories of students.

2. The Value Determination Model (VDM)

Unique to the Navy training problem is the determination of value as it applies to the military. While airlines measure value in revenue generated, the Navy currently has no way of placing value on a particular student attending a particular class. The concept of value is crucial to the implementation of yield management and quota control in NTQMS. The Value Determination Model developed in this thesis seeks to assign a numerical value to a heretofore unquantifiable entity. Figure 1 depicts the three primary inputs to the Quota Allocation Module which determines how many seats should be available to each of the different student types competing for space in a given class. These inputs are the authorized capacity from the Booking Level Authorization Module mentioned above, demand forecast from the Demand Forecast Model, and student value from the Value Determination Model.

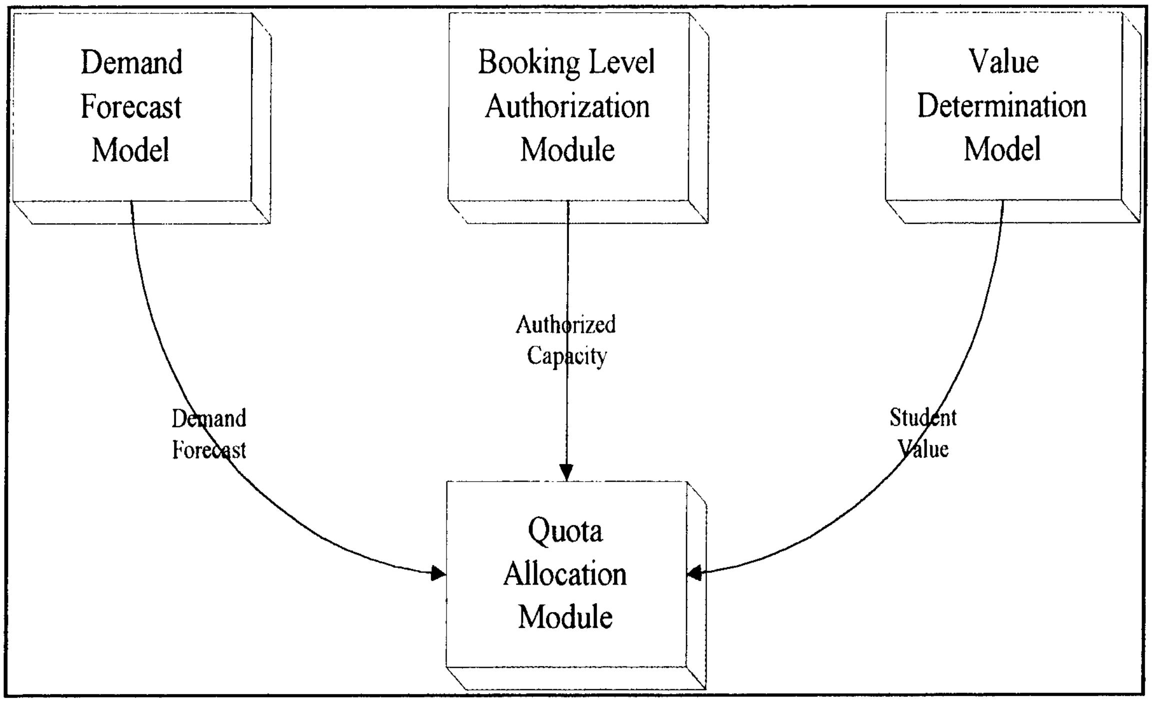

Figure 1. Inputs to Quota Allocation Module

C. PROBLEM EVOLUTION

The Value Determination Model (VDM) progressed through several iterations to result in the formulation described in Chapter IV. The following section is a chronicle of events encountered by the author (written in the first person) from inception of the VDM to its current version.

Naval Postgraduate School (NPS) involvement with the Value Determination Model began in the fall of 1995 when I spent my experience tour at SABRE Decision Technologies (SDT) in Fort Worth, Texas, funded by the Naval Personnel Research and Development Center (NPRDC). NPRDC had contracted SDT to develop all models within the Navy Training Quota Management System with the exception of the Value Determination Model. It was agreed that the VDM would be a joint effort between

NPRDC and a thesis student at NPS. After learning about yield management and NTQMS, I began the process of forming an initial outline of a VDM. My first step was to identify those factors which had an impact on determining student value. My original intent was to create a multi-dimensional array where each of the factors would be an entering argument into the array and the final value for that student would be the "intersection" of all the factors. Unfortunately, as with most real world problems, there were no data to support some of the factors I had identified as having an impact on student value. Any data used in the NTQMS had to be available within the Navy's primary training database, the Navy Integrated Training and Resource Administration System (NITRAS II).

The VDM then shifted from a multi-dimensional array to an algorithm where overall value for a student was the sum of each identified factor value, multiplied by a weighting coefficient. This model began with seven factors divided into two categories: student factors and class factors. The student factors were student type, criticality of Navy Enlisted Classification (NEC) being sought, and the type of orders written for the student (i.e. Permanent Change of Station (PCS), Temporary Assigned for Duty (TAD), or No Cost TAD). Class factors were course length, course periodicity, classroom elasticity and path. Path identifies a class as being either a stand-alone course of instruction or part of a pipeline of a sequence of courses required to obtain a specific skill. Classroom elasticity is whether or not the physical constraints of the classroom readily allow the addition of more students into the class, and if so, how many.

I returned to Monterey and began work on this iteration of the model. Subsequent

work led to another modification to the VDM. Since the values of the class factors are identical for each variation of student, it is irrelevant to include them as part of the VDM. The path (pipeline) factor was modified to reflect differences in student type. The final variation of the VDM focuses on four factors: student type, path, orders type, and NEC granted.

Chapter III details the factors as well as the methodology for combining them into a value determination model.

III. PROBLEM FORMULATION

As previously mentioned, the Navy trains over 350,000 students a year. When fully implemented, the Navy Training Quota Management System will be able to handle every course the Navy offers. For now, the scope of NTQMS is limited to solving the A and C-School quota management problem. An A-School is attended primarily, although not exclusively, by students who have just completed recruit training and provides basic skill instruction in a particular rate (job description). Every enlisted sailor above the pay grade of E-3 has a rate. Examples of a rate are Fire Controlman (FC), Hospital Corpsman (HM), and Quartermaster (QM). C-Schools provide more detailed training and are attended as a direct follow-on to A School or by more senior sailors with fleet experience. Graduates of C-Schools earn a Navy Enlisted Classification (NEC). An NEC is a code given to an individual to denote specialized training within a certain rate.

A. VALUE DETERMINATION MODEL FACTORS

1. Student Type

In the NITRAS II database, students are categorized into 51 different types, many of which are similar. In the VDM, these 51 types have been aggregated into 10 categories for A-Schools and 11 categories for C-Schools. This aggregation was agreed upon at a conference attended by subject matter experts from the Bureau of Naval Personnel (BUPERS), the Chief of Naval Education and Training (CNET), and Naval Education and Training Program Management Support Activity (NETPMSA). Student types in each category carry the same relative value. For instance, **Category One** consists of **United**

States Navy Active Duty forces while **Category Three** consists of **United States Navy Active Duty Training and Administration of Reserves (TAR)** forces. Table 2 shows the aggregated categories for both A and C-School student types.

A-School Student Types	C-School Student Types
USN Active Fleet	USN Active Regular
USN Active Recruit	USN Selected Reserves (SELRES)
USN Training and Administration of Reserves (TAR)	USN Training and Administration of Reserves (TAR)
USN Selected Reserves (SELRES)	Foreign National
Foreign National	US Army
US Army	US Marine Corps
US Marine Corps	US Air Force
US Air Force	US Coast Guard
US Coast Guard	DoD Civilian
Other	Naval Sea Systems Command Shipyard Industrial Design Center (NAVSEA SIDC)
	Other

Table 2. Aggregated Student Types

2. Path

Path differentiates between students who are scheduled to attend a sequence of courses, called a pipeline, and those who are only scheduled to take a portion of the sequence. A student scheduled to attend the entire pipeline has a different value than one attending a segment because a failure to show for the initial course can cause an empty seat to track through the entire pipeline. However, a student scheduled for only one segment who fails to show only creates spoilage for that one class. Figure 2 is an example

of possible student paths to achieve three different skill awards (a rate or NEC). Course A is common to all three skill awards and course C is common to both skill 2 and skill 3.

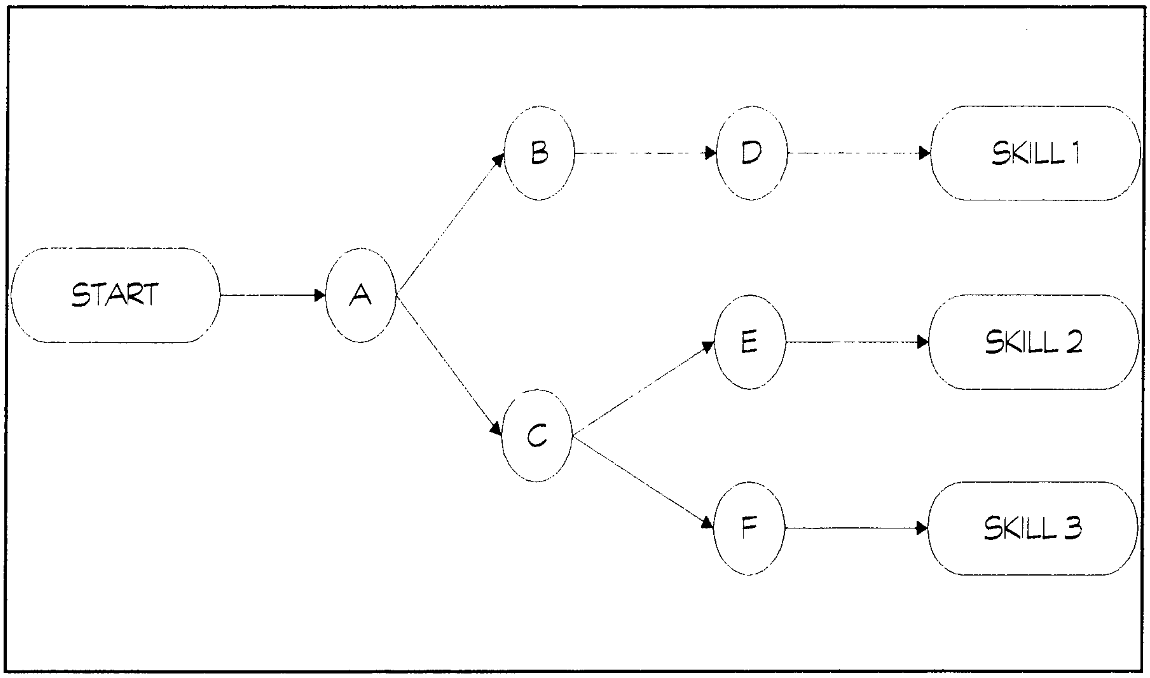

Figure 2. Diagram of possible student paths to achieve training

Consider an airline example of a flight that originates in San Francisco with a final destination of New York, but connects through Dallas. The airline would rather sell a seat on that flight to two different people, each flying one leg only, than to one person making the complete journey because it reduces the chance for spoilage. If the San Francisco passenger fails to show, there is still an opportunity for the Dallas passenger to occupy that seat for the second leg of the trip. Not only does this reduce spoilage but also generates more revenue because the sale price of the two segments sold separately is greater than the price of the trip sold to one passenger. The same situation is true for the Navy training problem.

3. Orders Type

Students arrive at the training site under different types of orders such as Permanent Change of Station (PCS) and Temporary Assigned for Duty (TAD). The Quota Status Codes in the Navy Integrated Training Resources Administration System (NITRAS) identify 10 different codes under which students receive training. PCS implies that the student is en route from one duty station to another with the training as an intermediate stop along the way. TAD orders indicate the student will return to the same parent command after training. The NITRAS codes also differentiate students receiving pipeline training as well as "sit-in" students. Students on TAD orders attending training in the same location as the parent command will travel under NO-COST TAD orders. Here, value can be associated with cost. When the decision must be made as to which student to choose among several competing for a single remaining seat, and all other factors are equal, orders type can be used to determine which student is more advantageously granted that final seat.

4. Rate/NEC

A Navy Enlisted Classification (NEC) is a code given to a student who completes a specific type of training and consequently possesses unique skills within his/her rating. The semi-annual Selective Reenlistment Bonus (SRB) message delineates monetary bonuses to be paid to NEC holders who reenlist. This message is an excellent method to determine which NEC's are more critical and consequently, more valuable. Changes in bonuses paid are generally minor from one SRB message to the next. Although NEC's are only granted to C-School graduates, the SRB message can also be used for the A-

School allocation decision by limiting the categorization to rate only and not to the more specific NEC. In the case where several students are competing for the last available quota, and all other factors are identical with the exception of Rate/NEC, that student who is requesting the training to obtain a more critical Rate/NEC is the better choice for that last quota.

B. DETERMINING OVERALL VALUE

After the methodologies for determining the values for the factors have been identified, the next step is to combine them into a final determination of value for that student. Here, the question becomes: how much importance does one factor, such as student type, have relative to another, such as Rate/NEC granted? To handle this, the VDM explores how different weighing schemes of each factor affect the final determination.

IV. METHODOLOGY

This chapter examines the four factors in the Value Determination Model and details the use of the Constant Sum Method as a tool to arrive at an hierarchical ranking of the Student Value factor. To obtain data for the Student Type factor, the surveys in Appendices A and B were distributed to the subject matter experts mentioned in Chapter III. Unfortunately, only three completed surveys were returned. The surveys were then given to students at the Naval Postgraduate School in order to generate sufficient data to demonstrate the methodology. The analysis presented in the remaining chapters was perfomed using the results from the 15 combined responses. The methodology for the remaining three factors is outlined using hypothetical data. The technique for collecting the data for the Orders Type factor and the weighting coefficients is identical to the Student Type factor, which consists of drafting a survey to include all pairwise comparisons and applying the Constant Sum Method to the survey data. Data for the remaining two factors (Path Type and Rate/NEC) are quantitative in nature and the methodology for determining their values is presented below. Finally, a mechanism for combining the factors is explored using sensitivity analyses presented in Chapter V.

A. STUDENT VALUE

Suppose an individual is given 10 objects of similar size, but differing weights, and is asked to place the objects in order from heaviest to lightest. With the use of a scale, the individual could easily perform the assigned task. However, to perform the task without the use of a scale, the subject could be asked to make judgements about the respective

weights of the objects. The individual could be presented the objects in all possible pairs and asked to judge which member is heavier. Based on the average judgements of a large group of individuals, the objects could be ordered from heaviest to lightest. The ordering of objects upon the basis of judgements is said to be on a psychological continuum. This method is generally known as a psychological scaling method. The problem of psychological scaling is then to determine whether n objects (stimuli) can be ordered on a psychological continuum with respect to the degree of the attribute each possesses. (Edwards, 1957)

The Constant Sum Method employs data from pairwise comparisons in order to determine the relative ranking of items of interest, with regard to their possession of a common property or contribution to a particular function. Subject Matter Experts (SME's) are asked to consider n elements in pairs with regard to a certain common property. All possible pairs are presented for consideration, for a total of $[n(n-1)]/2$ pairs. Therefore, the Constant Sum Method is best applied to a relatively small number of elements, generally less than 15. More comparisons than this would result in a survey too lengthy for SME's to complete. (Guadalupe, 1988)

Relating this technique to the problem of ranking student types requires combining the 51 original student types into broader categories containing similar student types. Normally, in the Constant Sum Method, SME's are asked to split 100 points between each pair. This large scale often makes it difficult for SME's to differentiate between items. This survey uses a smaller range of point values of 1 to 9. This reduction in the range has been shown to be valid by Saaty:

> Experience has confirmed that a scale of nine units is reasonable and reflects the degree to which we can discriminate the intensity of relationships between elements. (Saaty, 1980)

The following is a list of intensity values and their descriptions as it applies to the Student Type Survey.

INTENSITY VALUE	DEFINITION	EXPLANATION
1	Equal importance	Training each of these Student Types **contributes equally** to improving Navy readiness.
3	Weak importance of one over the other	Your experience and judgement tell you that one Student Type would produce **moderately more benefit** than the other.
5	Essential or strong importance	Experience and judgment tell you that one Student Type would produce **significantly more benefit** than the other.
7	Very strong importance	One Student Type provides a **very significant benefit** over the other; its dominance is obvious from experience.
9	Absolute importance	Your unqualified opinion is that there is the **highest order of benefit** for one Student Type over the other.
2, 4, 6, 8	Intermediate values between two adjacent intensities	When you must compromise.

The Constant Sum Method is used to estimate the rank order of the stimuli. The mean of the results associated with Student Type i from the completed surveys is taken as the *scale value* of the stimulus and is designated S_i. In other words, the estimate of the mean weight (scale value) given to one student type by all the SME's allows its relationship to the other student types to be determined. This is accomplished in the following manner.

The raw data collected from the completed survey are converted to an n x n matrix where rows are compared against columns. In other words, the intensity value, X, in position [i,j] relates to student type i being preferred to student type j by a value of X. This matrix is then converted to a 100 point scale by:

Intensity value awarded to preferred student type	=	(intensity value x 100) / (intensity value + 1)
Intensity value awarded to other component in pair	=	100 - above result

Each SME's resulting matrix is then a 100-point split equivalent to the intensity value, where a_{ij} is the number of points awarded to student type i when compared to type j and a_{ji} is the number of points awarded to student type j in that same comparison. An intensity value of 1 translates into a 50 point split between each of the two student types in the compared pair. Likewise, each element of the diagonal is also assigned a converted value of 50.

Taking an average of all elements over a total of m SME's, one composite matrix is formed, called **AB** where

$$\bar{a}_{ij} = \frac{\sum_{k=1}^{m} a_{ijk}}{m} \quad (k \textit{ denotes subject matter expert}) \tag{1}$$

The aggregation of the SMEs' responses is used for all remaining calculations, so that, hereafter, the number of judges is suppressed. Therefore, this method can be used with the responses of any number of judges.

The next step in the Constant Sum Method is to compute a new n x n matrix, **W**, using the following equation:

$$W_{ij} = \frac{\bar{a}_{ij}}{\bar{a}_{ji}} \tag{2}$$

where the cross-diagonal elements in the **W** matrix are reciprocals of each other. The ratio of a_{ij} to a_{ji} is the ratio of the estimated scale value of item j to the estimated scale value of item i. Therefore, from equation (2):

$$W_{ij} = \textit{estimate of} \left| \frac{S_j}{S_i} = \frac{\textit{Scale value for Student Type } j}{\textit{Scale value for Student Type } i} \right| \tag{3}$$

Assuming that the responses by the subject matter experts provide a perfect estimate for S_j / S_i, we can take natural logarithms of the equality, resulting in:

$$\ln W_{ij} - (\ln S_j - \ln S_i) = 0 \tag{4}$$

If n, the number of components analyzed, is greater than three, there will be more

estimating equations than there are scale values to estimate. The method of least squares is employed to resolve this problem. The difference between the natural log of **W** value (the estimate of the ratio of the scale values) and the natural log of the true ratio of the scale values is minimized using the derivative of the natural logarithm form of equation (4). The steps below show how the least squares method is used. (Lindsay, 1980, pp 3-4 of Constant Sum Method)

Scale values are sought which satisfy the following:

Min (Q)

where

$$Q = \sum_{i=1}^{n} \sum_{j=1}^{n} [\ln W_{ij} - (\ln S_i - \ln S_j)]^2 \qquad \textbf{(5)}$$

Taking the partial derivatives of equation (5) with respect to S_i, setting $\delta X / \delta S_i = 0$, and solving for ln S_i results in (after some algebra) equation (6):

$$\ln S_i = \frac{\sum_{j=1}^{n} \ln W_{ij}}{n} + \frac{\sum_{j=1}^{n} \ln S_j}{n} \quad i=1,2,\ldots,n \qquad \textbf{(6)}$$

Since the origin for our scale is arbitrary, we choose a unit by setting the average of the logs of the scale values at zero, or:

$$\frac{\sum_{j=1}^{n} \ln S_j}{n} = 0 \qquad \textbf{(7)}$$

Substituting the result of equation (7) into equation (6), the least squares estimates of the scale values become

$$\ln S_i = \frac{\sum_{j=1}^{n} \ln W_{ij}}{n} \qquad i = 1,2,\ldots,n \qquad \textbf{(8)}$$

Solving for individual S_i's shows that each scale value is equal to the geometric mean of the values of the corresponding column in the **W** matrix, or

$$S_i = \left[\prod_{j=1}^{n} [W_{ij}]\right]^{1/n} \qquad i = 1,2,\ldots,n \qquad \textbf{(9)}$$

Appendix C contains the results of the Constant Sum Method using the survey data.

B. PATH / ORDERS TYPE / NEC

1. Path

The position of a course within a pipeline of length n can be used as the determinant of the path factor value. This method relates value to the opportunity to incur spoilage costs as a function of a course's position. For example, consider a pipeline course of instruction consisting of three individual classes: A, B, and C. A student must attend all three classes of the pipeline *in sequence* to be awarded a particular NEC or rate. Figure 3 is a graphical representation of this pipeline where each node is a class within the

pipeline.

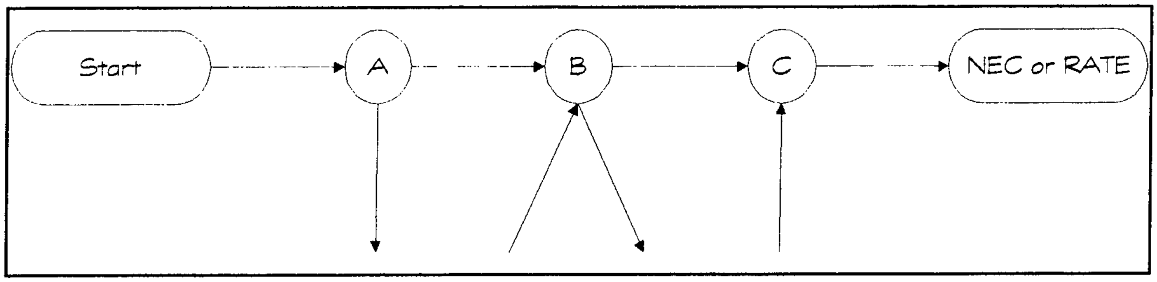

Figure 3. Graphical Representation of a Pipeline Course of Instruction

Not all students will attend classes A, B, and C without an interruption or break(s) in the continuity of the sequence. Some students may attend classes A and B and return later to take class C, for example. For this reason, each class can be expected to be filled by some students who are taking the class as a complete sequence and by others that may be attending that class as a stand-alone course of instruction. The arrows entering and/or leaving each of the nodes represent students taking something less than the complete consecutive sequence. The path factor value then becomes a function of the possible spoilage cost associated with the student. If a student booked for the entire pipeline fails to show for course A, his sold, but unfilled seat, will track through the whole sequence. (It is assumed that the model will be unable to resell the student's unfilled seat in courses B and C by the time they convene to avoid spoilage occuring in these courses.) This event has a higher spoilage cost than a student who is booked but fails to show for an individual segment class only. Likewise, an attrition from the pipeline after course B has less of an impact than an attrition occurring after course A. Path factor values can then be represented in the following table, where the notation ABC|A describes a student booked for the entire sequence, having already completed course A.

Booked Pipeline Sequence	Relative Value
ABC	High
ABC|A, AB, BC	Medium
ABC|AB, AB|A, BC|B, A, B, C	Low

Table 3. Relative Values Associated With Different Pipeline Sequences

Thus, numerical values can be assigned, using the equation

$$\text{Path Value} = \text{Classes Booked} - \text{Classes Attended}$$

Sensitivity to the actual numerical assignments of relative value is examined in Chapter V.

2. Orders Type

The Constant Sum Method of Pairwise Comparisons detailed above can be used to determine the hierarchical ranking of the ten Quota Status Codes in the NITRAS database. This thesis uses the three predominant categories of PCS, TAD, and NO-COST TAD and assigns hypothetical values to each.

3. NEC

The Selective Reenlistment Bonus message is an excellent tool for determining the relative importance of one NEC (and consequently, rate) over another. A sample of an SRB message is shown in Appendix D There are three main categories of reenlistment bonuses paid. Using a relative ranking scale of High, Medium, and Low, sensitivity to the actual numerical assignments similar to the Path factor above is examined in Chapter V.

C. COMBINING THE FACTORS

Assuming that all the factors have values, the next step is to develop a methodology for combining them to produce a single value model. The algorithm used is given in equation (10).

$$VALUE = \alpha StudentType + \beta PathType + \gamma OrdersType + \delta NEC \quad \textbf{(10)}$$

where the coefficients are weighting factors. The Constant Sum Method can be used to determine the hierarchical ranking of the different factors where SME's are again asked to judge the relative importance of each of the factors. Chapter V also explores the sensitivity of the overall student value using different weighting schemes.

V. SENSITIVITY ANALYSIS

A. ANALYSIS

This chapter provides a demonstration of the methodology described in Chapter IV through sensitivity analysis using the data from the A-School Student Type survey results (Appendix C) and hypothetical data for the other factors. Table 4 is a display of the raw data.

	Student Type		Path Type		Orders Type		Rate/NEC Type
Active Fleet	4.14	**High**	3	**PCS**	3	**Cat 1**	3
Active Recruit	3.51	**Medium**	2	**TAD**	2	**Cat 2**	2
USN TAR	2.09	**Low**	1	**No-Cost**	1	**Cat 3**	1
USN SELRES	1.68						
Foreign National	0.43						
US Army	0.44						
US Marine Corps	1.54						
US Air Force	0.41						
US Coast Guard	0.62						
Other	0.27						

Table 4. Raw Data. The values in the Student Type Category were determined by the Constant Sum Method. The values in the other three columns are hypothetical.

The first step is to normalize the raw data to a [0,1] scale. Since the Constant Sum method only produces a relative weighting and ranking, normalization is a valid operation and, since data for all of the factors are ratio scale, it is appropriate to normalize data to a [0,1] scale. For this demonstration, the normalized values are used as "base case" values. The base case values for the weighting coefficients are also hypothetical and were estimated from the author's personal experience. Table 5 shows the normalized base case values for each of the factors, as well as the weighting coefficients.

	Student Type		Path Type		Orders Type		Rate/NEC Type
Active Fleet	1	**High**	1	**PCS**	1	**Cat 1**	1
Active Recruit	0.85	**Medium**	0.67	**TAD**	0.67	**Cat 2**	0.67
USN TAR	0.5	**Low**	0.33	**No-Cost**	0.33	**Cat 3**	0.33
USN SELRES	0.41						
Foreign National	0.1		α	β	γ	δ	
US Army	0.11		1	0.7	0.1	0.3	
US Marine Corps	0.37						
US Air Force	0.1						
US Coast Guard	0.15						
Other	0.07						

Table 5. Normalized Data, Base Case

To conduct a sensitivity analysis, a variant point scheme for each factor other than Student Type and the weighing coefficients is compared separately against the base case. Because the Student Type values were obtained by the Constant Sum method using actual subjects, no variant was used for this factor.

For sensitivity analysis, a single variant from the base case was used for Path Type, Orders Type, Rate/NEC Type, and the weighting coefficients, resulting in five cases. Table 6 shows the variant point allocation for each of the factors.

	Student Type		Path Type		Orders Type		Rate/NEC Type
Active Fleet	1	**High**	0.2	**PCS**	0.75	**Cat 1**	1.0
Active Recruit	0.85	**Medium**	0.2	**TAD**	1	**Cat 2**	1.0
USN TAR	0.5	**Low**	1.0	**No-Cost**	0.1	**Cat 3**	0.4
USN SELRES	0.41						
Foreign National	0.1						
US Army	0.11						
US Marine Corps	0.37						
US Air Force	0.1						
US Coast Guard	0.15						
Other	0.07						

Table 6. Variant Point Distributions

In the "Path Type" category, the variant point allocation reflects the notion that

no-shows in the "High" and "Medium" zones create a higher potential to incur a spoilage cost than in the "Low" zone and therefore, are not weighted as heavily as a "Low" possibility of a seat being unfilled when a class convenes. Stated another way, the potential for more than a one course path to result in spoilage is unacceptable. Therefore, more value is placed on filling the class with students who are only taking one segment of the pipeline, since the chance of incurring spoilage cost is reduced for this case. Note that the reasoning for the weights in the variant case for Path Type is reversed from the base case, where higher value was placed on longer path sequences as opposed to spoilage cost.

In the "Orders Type" category the base case point allocation places the most emphasis on training those students who are attending a course as part of a Permanent Change of Station (PCS) move. This distribution reflects students with PCS orders that are en route to a final duty station to fill a vacant billet that requires an individual who has completed prerequisite training. This may or <u>may not</u> be true for the TAD student which is given two-thirds the PCS point value. The variant weighting scheme for "Orders Type" places more emphasis on students attending training under TAD orders, while No-Cost orders are given very little value. This point allocation reflects how long TAD courses (greater than 100 but less than 120 days) that do not qualify as a PCS move may cost more in per diem and allowances; and therefore, for some classes it is more important to fill the classes with students attending under TAD orders ahead of their PCS counterparts.

The base case point distribution for the Rate/NEC factor is a direct reflection of the reenlistment bonuses paid. Those rates/NEC's that generate larger bonuses are given

higher weights. The variant point allocation for the "Rate/NEC" category reflects equal and significant weight put on category 1 and 2 students, while category 3 students are valued less. The rationale behind the variant case reflects how the majority of all reenlistments fall into category 3 and only a few rates/NEC's warrant substantial bonuses. Even though there is a difference in the bonuses paid between categories 1 and 2, the difference is small when compared to category 3 bonuses.

The base case and the variant point distribution for the weighing factors is shown in Table 7. The base case reflects the Student Type and Path Type factors affecting overall student value to a much higher degree than the remaining two (Orders Type and Rate/NEC) because these two factors are more likely to exhibit large variations between competing students. In the variant, Student Type alone is considered the dominating factor, while Path Type is reduced in importance to be roughly equal to the remaining factors, to illustrate instances where the only real variable of the student characteristics is Student Type.

	α	β	γ	δ
Base Case	1	0.7	0.1	0.3
Variant	1	0.3	0.2	0.2

Table 7. Base Case and Variant of the Weighting Coefficients

To illustrate how these point variants affect overall student value, five hypothetical student profiles have been created, each possessing different characteristics given in Table 8.

Adams, John	Brown, Tim	Carnes, Andy	Drumm, Mary	Escher, Hans
Active Fleet	USN TAR	US Coast Guard	Active Recruit	Foreign National
High Path	Medium Path	High Path	Low Path	High Path
PCS	TAD	No-Cost	No-Cost	PCS
Category 1	Category 2	Category 3	Category 3	Category 3

Table 8. Sample Student Characteristics

Using equation (10) from Chapter IV, overall student value is determined for the base case and each variant. The student values for the five cases are shown in Table 9.

Student	Base Case	Path Variant	Orders Variant	Rate/NEC Variant	Weight Variant
Adams	2.1	1.54	2.075	2.1	1.7
Brown	1.237	0.908	1.27	1.336	0.969
Carnes	1.049	0.489	1.024	1.07	0.716
Drumm	1.213	1.682	1.19	1.234	1.081
Escher	0.999	0.439	0.974	1.02	0.666

Table 9. Overall Student Value for Sample Students for Base Case and Each Variant

B. OBSERVATIONS

In most cases the ranking of students remains fairly constant. The Foreign National student always ranks last and the Active Fleet student is generally first. However, when more emphasis is placed on avoiding a spoilage cost (Path Variant), the Active Recruit student becomes the most valuable even though she is low in the Orders Type and NEC/Rate factors. This is the result of the reversed weighting scheme in the Path Variant.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The goal of this thesis is to propose a methodology for determining student value in an effort to apply the principles of yield management to the Navy training quota management problem. The techniques outlined in the previous chapters can be used to obtain a sense of the relative importance of different factors and a relative ranking of students based on the VDM. It has been shown how the Constant Sum Method of Paired Comparisons can be used to determine a hierarchical ranking and relative value of items with regard to their possession of a common property through the use of a survey and subject matter experts.

This methodology can be readily expanded to include more factors. However, whenever an additional factor is added, the Constant Sum Method must be repeated to include the new factor, in particular to determine the new values of the weighting coefficients.

B. RECOMMENDATIONS

The mathematics of the Method of Paired Comparisons is computationally simple. The real difficulty in using this technique is finding a sufficient number of subject matter experts who are willing to participate and supply their opinion in the form of a completed survey. Although this technique can be applied using any number of Subject Matter Experts, the more judges that respond, the greater the validity of the data.

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APPENDIX A. A-SCHOOL SURVEY

SURVEY INSTRUCTIONS

You are a Navy Training Quota Manager and must decide which **A-School** student types best meet the Navy's need to improve readiness. You are asked to compare two student types to each other, with regard to which of the two would result in more benefit to readiness if both were chosen. In addition, you will give your comparison a number to designate how much more benefit the one you chose would produce. The following are descriptions of the possible "intensity values" you may choose for each pair.

INTENSITY VALUE	DEFINITION	EXPLANATION
1	Equal importance	Training each of these Student Types **contributes equally** to improving Navy readiness.
3	Weak importance of one over the other	Your experience and judgement tell you that one Student Type would produce **moderately more benefit** than the other
5	Essential or strong importance	Experience and judgment tell you that one Student Type would produce **significantly more benefit** than the other
7	Very strong importance	One Student Type provides a **very significant benefit** over the other; its dominance is obvious from experience
9	Absolute importance	Your unqualified opinion is that there is the **highest order of benefit** for one Student Type over the other
2,	Intermediate values	When you must compromise

4,	between two adjacent
6,	intensities
8	

STUDENT TYPE DEFINITIONS

USN Active Fleet - Navy students on **active duty** attending A-School **from a Fleet billet**

USN Active Recruit - **Navy** students on **active duty** attending A-School **directly from Recruit training**

USN TAR - **Navy** students attending A-School on **active duty** designated **USNR-TAR** (Training and Administration of Reserves)

USN Selected Reserve (SELRES) - **Naval Reservists** (both USNR-Active and USNR-R) attending A-School

Foreign National - Foreign students funded by their parent country receiving training in U.S. Navy Schools

US Army - Army personnel receiving training in Navy schools

US Marine Corps - Marine Corps personnel receiving training in Navy schools

US Air Force - Air Force personnel receiving training in Navy schools

US Coast Guard - Coast Guard personnel receiving training in Navy schools

Other - All other student types attending A-School

Please compare each of the following pairs of student types, a pair at a time, independently of any of the other pairs. Choose the letter X or Y, which corresponds to the student type in that pair which would cause the most benefit to readiness if both were able to be chosen. Then select one of the "intensity values" described above to show the extent of the comparison. (If you feel that training both would cause equal benefit to readiness, write both the letters "X" and "Y", and place a "1" in the column marked "Intensity Value".) **DO NOT CHANGE A RESPONSE ONCE YOU HAVE MARKED IT DOWN!**

X	Y	If **one** quota remains in a given class, more benefit would be gained by training student type:	Intensity value
USN Active Fleet	USN Active Recruit		
USN TAR	USN Active Fleet		
USN Active Fleet	USN Selected Reserve		
Foreign National	USN Active Fleet		
USN Active Fleet	US Army		
US Marine Corps	USN Active Fleet		
USN Active Fleet	US Air Force		
US Coast Guard	USN Active Fleet		
USN Active Fleet	Other		
USN TAR	USN Active Recruit		
USN Active Recruit	USN Selected Reserve		

X	Y	If **one** quota remains in a given class, more benefit would be gained by training student type:	Intensity value
Foreign National	USN Active Recruit		
USN Active Recruit	US Army		
US Air Force	USN Active Recruit		
USN Active Recruit	US Marine Corps		
US Coast Guard	USN Active Recruit		
USN Active Recruit	Other		
USN Selected Reserve	USN TAR		
USN TAR	Foreign National		
US Army	USN TAR		
USN TAR	US Marine Corps		
US Air Force	USN TAR		
USN TAR	US Coast Guard		
Other	USN TAR		

X	Y	If **one** quota remains in a given class, more benefit would be gained by training student type:	Intensity value
USN SELRES	Foreign National		
US Army	USN SELRES		
USN SELRES	US Marine Corps		
US Air Force	USN SELRES		
USN SELRES	US Coast Guard		
Other	USN SELRES		
Foreign National	US Army		
US Marine Corps	Foreign National		
Foreign National	US Air Force		
US Coast Guard	Foreign National		
Foreign National	Other		
US Marine Corps	US Army		
US Army	US Air Force		

X	Y	If **one** quota remains in a given class, more benefit would be gained by training student type:	Intensity value
US Coast Guard	US Army		
US Army	Other		
US Air Force	US Marine Corps		
US Marine Corps	US Coast Guard		
Other	US Marine Corps		
US Air Force	US Coast Guard		
Other	US Air Force		
US Coast Guard	Other		

Comments:

APPENDIX B. C-SCHOOL SURVEY

SURVEY INSTRUCTIONS

You are a Navy Training Quota Manager and must decide which **C-School** student types best meet the Navy's need to improve readiness. You are asked to compare two student types to each other, with regard to which of the two would result in more benefit to readiness if both were chosen. In addition, you will give your comparison a number to designate how much more benefit the one you chose would produce. The following are descriptions of the possible "intensity values" you may choose for each pair.

INTENSITY VALUE	DEFINITION	EXPLANATION
1	Equal importance	Training each of these Student Types **contributes equally** to improving Navy readiness.
3	Weak importance of one over the other	Your experience and judgement tell you that one Student Type would produce **moderately more benefit** than the other
5	Essential or strong importance	Experience and judgment tell you that one Student Type would produce **significantly more benefit** than the other
7	Very strong importance	One Student Type provides a **very significant benefit** over the other; its dominance is obvious from experience
9	Absolute importance	Your unqualified opinion is that there is the **highest order of benefit** for one Student Type over the other
2,	Intermediate values	When you must compromise

4, 6, 8	between two adjacent intensities

STUDENT TYPE DEFINITIONS

USN Active Regular - Navy students on **active duty** attending C-School

USN TAR - Navy students attending C-School on **active duty** designated **USNR-TAR** (Training and Administration of Reserves)

USN Selected Reserve (SELRES) - Naval Reservists (both USNR-Active and USNR-R) attending C-School

Foreign National - Foreign students funded by their parent country receiving training in U.S. Navy Schools

US Army - Army personnel receiving training in Navy schools

US Marine Corps - Marine Corps personnel receiving training in Navy schools

US Air Force - Air Force personnel receiving training in Navy schools

US Coast Guard - Coast Guard personnel receiving training in Navy schools

DoD Civilian - Civilian employee of a Department of Defense agency attending a C-School

NAVSEA SIDC - Naval Sea Systems Shipyard Instructional Design Center, shipyard employees (civilians) that attend certain "C" schools for specialized training

Other - All other student types attending C-School

Please compare each of the following pairs of student types, a pair at a time, independently of any of the other pairs. Choose the letter X or Y, which corresponds to the student type in that pair which would cause the most benefit to readiness if both were able to be chosen. Then select one of the "intensity values" described above to show the extent of the comparison. (If you feel that training both would cause equal benefit to readiness, write both the letters "X" and "Y", and place a "1" in the column marked "Intensity Value".) **DO NOT CHANGE A RESPONSE ONCE YOU HAVE MARKED IT DOWN!**

X	Y	If **one** quota remains in a given class, more benefit would be gained by training student type:	Intensity value
USN Active	USN TAR		
USN Active	USN Selected Reserve		
Foreign National	USN Active		
USN Active	US Army		
US Marine Corps	USN Active		
USN Active	US Air Force		
US Coast Guard	USN Active		
USN Active	DoD Civilian		
NAVSEA SIDC	USN Active		
USN Active	Other		
USN Selected Reserve	USN TAR		
USN TAR	Foreign National		
US Army	USN TAR		

X	Y	If **one** quota remains in a given class, more benefit would be gained by training student type:	Intensity value
USN TAR	US Marine Corps		
US Air Force	USN TAR		
USN TAR	US Coast Guard		
DoD Civilian	USN TAR		
USN TAR	NAVSEA SIDC		
Other	USN TAR		
USN SELRES	Foreign National		
US Army	USN SELRES		
USN SELRES	US Marine Corps		
US Air Force	USN SELRES		
USN SELRES	US Coast Guard		
DoD Civilian	USN SELRES		
USN SELRES	NAVSEA SIDC		

X	Y	If **one** quota remains in a given class, more benefit would be gained by training student type:	Intensity value
Other	USN SELRES		
Foreign National	US Army		
US Marine Corps	Foreign National		
Foreign National	US Air Force		
US Coast Guard	Foreign National		
Foreign National	DoD Civilian		
NAVSEA SIDC	Foreign National		
Foreign National	Other		
US Marine Corps	US Army		
US Army	US Air Force		
US Coast Guard	US Army		
US Army	DoD Civilian		
NAVSEA SIDC	US Army		

X	Y	If **one** quota remains in a given class, more benefit would be gained by training student type:	Intensity value
US Army	Other		
US Air Force	US Marine Corps		
US Marine Corps	US Coast Guard		
DoD Civilian	US Marine Corps		
US Marine Corps	NAVSEA SIDC		
Other	US Marine Corps		
US Air Force	US Coast Guard		
DoD Civilian	US Air Force		
US Air Force	NAVSEA SIDC		
Other	US Air Force		
US Coast Guard	DoD Civilian		
NAVSEA SIDC	US Coast Guard		
US Coast Guard	Other		

X	Y	If **one** quota remains in a given class, more benefit would be gained by training student type:	Intensity value
DoD Civilian	NAVSEA SIDC		
Other	DoD Civilian		
NAVSEA SIDC	Other		

Comments:

APPENDIX C. SURVEY RESULTS USING THE CONSTANT SUM METHOD

RAW DATA

(judge #2)	USN Active Fleet	USN Active Recruit	USN TAR	USN SELRES	Foreign National	US Army	Marine Corps	Air Force	Coast Guard	Other
USN Active Fleet		1	1	7	1	9	1	9	9	9
USN Active Recruit	1		1	1	1	9	1	9	9	9
USN TAR	1	1		1	1	9	1	9	9	9
USN SELRES		1	1		1	9	1	9	9	9
Foreign National	1	1	1	1		9	1	9	9	9
US Army								1	1	1
Marine Corps	1	1	1	1	1	9		9	9	9
Air Force						1			1	1
Coast Guard						1		1		1
Other						1		1	1	

Raw Data	50.00	50.00	50.00	87.50	50.00	90.00	50.00	90.00	90.00	90.00
Converted	50.00	50.00	50.00	50.00	50.00	90.00	50.00	90.00	90.00	90.00
to 100	50.00	50.00	50.00	50.00	50.00	90.00	50.00	90.00	90.00	90.00
Point	12.50	50.00	50.00	50.00	50.00	90.00	50.00	90.00	90.00	90.00
Scale	50.00	50.00	50.00	50.00	50.00	90.00	50.00	90.00	90.00	90.00
	10.00	10.00	10.00	10.00	10.00	50.00	10.00	50.00	50.00	50.00
	50.00	50.00	50.00	50.00	50.00	90.00	50.00	90.00	90.00	90.00
	10.00	10.00	10.00	10.00	10.00	50.00	10.00	50.00	50.00	50.00
	10.00	10.00	10.00	10.00	10.00	50.00	10.00	50.00	50.00	50.00
	10.00	10.00	10.00	10.00	10.00	50.00	10.00	50.00	50.00	50.00

AB	50	65.104167	73.438	84.47917	82.8125	89.0625	73.5417	88.75	88.2292	89.0625
Matrix	34.895833	50	75.521	79.6875	82.8125	88.75	77.7778	88.75	87.9167	89.0625
	26.5625	24.479167	50	65.10417	76.25	87.395833	63.5417	87.916667	77.9167	88.006
	15.520833	20.3125	34.896	50	73.854167	85.694444	62.1528	85.833333	86.875	86.7708
	17.1875	17.1875	23.75	26.14583	50	33.229167	24.2708	33.229167	32.1875	55
	10.9375	11.25	12.604	14.30556	66.770833	50	18.3333	54.6875	31.25	72.5149
	26.458333	31.597222	36.458	37.84722	75.729167	81.666667	50	82.708333	74.2361	88.2292
	11.25	11.25	12.083	14.16667	66.770833	45.3125	17.2917	50	28.6954	73.0357
	11.770833	12.083333	22.083	13.125	67.8125	68.75	25.7639	71.304563	50	73.3333
	10.9375	10.9375	11.994	13.22917	45	27.485119	11.7708	26.964286	26.6667	50

W	1	1.8656716	2.7647	5.442953	4.8181818	8.1428571	2.77953	7.8888889	7.49558	8.14286
Matrix	0.536	1	3.0851	3.923077	4.8181818	7.8888889	2.46154	7.8888889	7.27586	8.14286
	0.3617021	0.3241379	1	1.865672	3.2105263	6.9338843	1.74286	7.2758621	3.5283	7.33747
	0.1837238	0.254902	0.536	1	2.8247012	5.9902913	1.6422	6.0588235	6.61905	6.55906
	0.2075472	0.2075472	0.3115	0.35402	1	0.4976599	0.3205	0.4976599	0.47465	1.22222
	0.122807	0.1267606	0.1442	0.166937	2.0094044	1	0.22449	1.2068966	0.45455	2.63833
	0.3597734	0.40625	0.5738	0.608939	3.1201717	4.4545455	1	4.7831325	2.8814	7.49558
	0.1267606	0.1267606	0.1374	0.165049	2.0094044	0.8285714	0.20907	1	0.40243	2.70861
	0.133412	0.1374408	0.2834	0.151079	2.1067961	2.2	0.34705	2.4848747	1	2.75
	0.122807	0.122807	0.1363	0.152461	0.8181818	0.3790273	0.13341	0.3691932	0.36364	1

Scale Values, S_i, of the Survey Results Using Equation (9) from Chapter IV

USN Active Fleet	4.138612
USN Active Recruit	3.509817
USN TAR	2.09109
USN SELRES	1.68406
Foreign National	0.430517
US Army	0.435374
Marine Corps	1.536469
Air Force	0.411228
Coast Guard	0.621731
Other	0.265503

APPENDIX D. EXERPTS FROM SELECTED REENLISTMENT BONUS MESSAGE (NAVADMIN 111/96 022358Z MAY 96)

30,000 Dollar Level Ceiling	
SKILL	**NEC**
CTI	9197
CTI	9209
CTI	9211
CTI	9216
CTM	9238
CTM	9249
FC	1105
FC	1108
FC	1121
FC	1130
⋮	⋮

20,000 Dollar Level Ceiling	
SKILL	**NEC**
AC	0000
AE	0000
AG	7412
AT	0000
AT	6628
AT	6650
AT	6673
AT	6684
AT	6689

AT	6695
AT	6718
⋮	⋮

10,000 Dollar Level Ceiling

SKILL	**NEC**
ALL OTHERS	ALL OTHERS

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